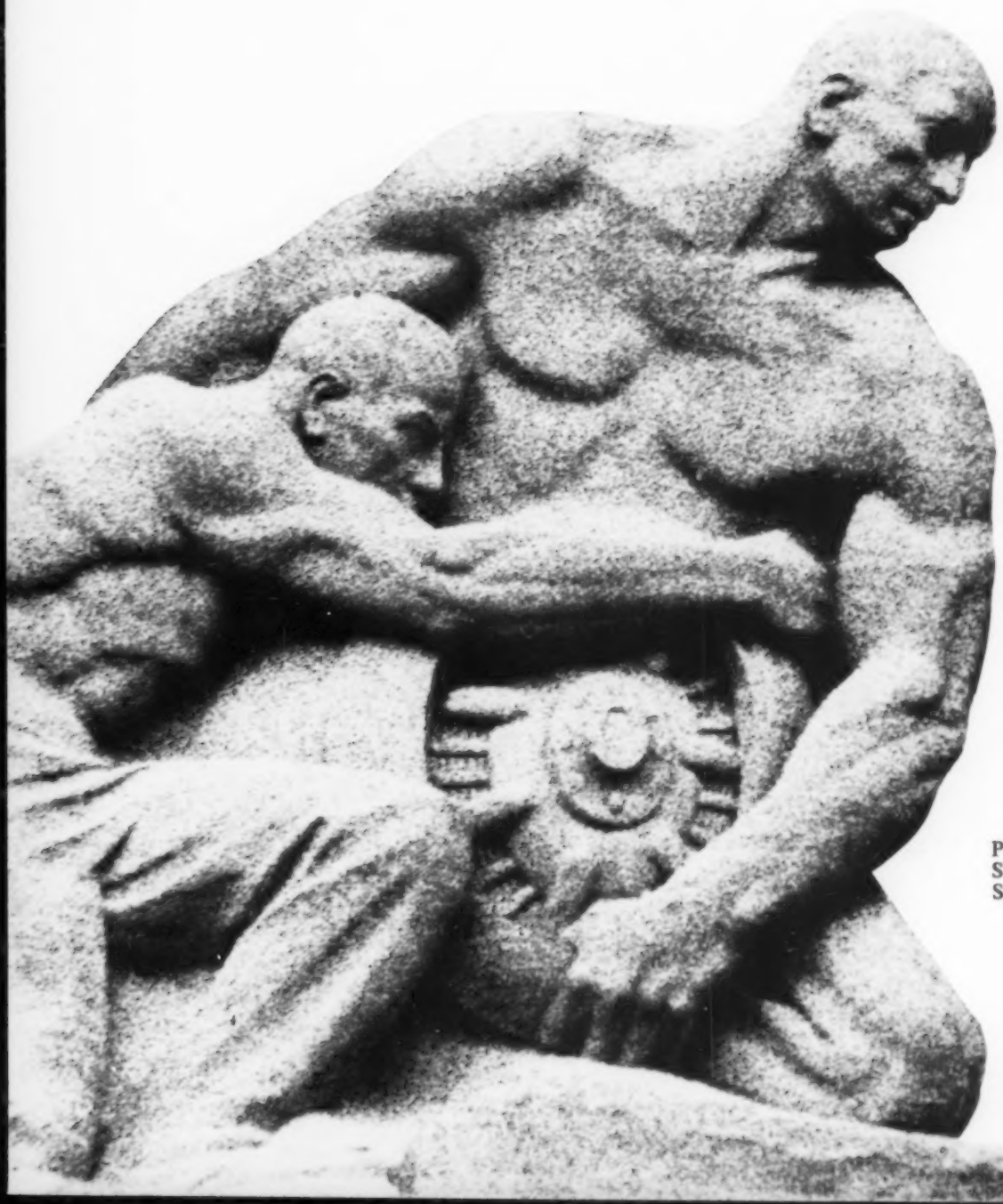
DIMENSIONS NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

August 1977



PRESERVING STONE.
See page 2.

COMMENT

MATERIALS RESEARCH

Materials research at the National Bureau of Standards began in 1901 with the establishment of NBS. Our enabling legislation states (in addition to much other wisdom) that:

> "the functions of the bureau shall consist in . . . the determination of physical constants and the properties of materials, when such data are of great importance to scientific and manufacturing interests. . . ."

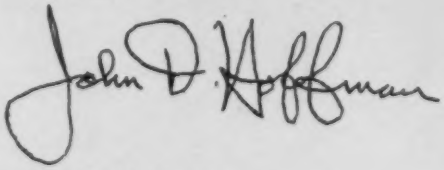
The growth of materials research efforts at NBS since this directive has led to an Institute for Materials Research with a full-time permanent staff of 340 professionals and 140 supporting personnel.

In every issue of DIMENSIONS/NBS there is at least one article, report, or notice on materials research. On page 20 of this issue, you will find a discussion of one important Standard Reference Materials program being conducted with a research associate from the American Society for Testing and Materials. On page 22 is a report of new findings on the molecular structure of particulates from power plants, obtained with an NBS Raman microprobe.

At first glance, these articles appear to be unrelated; however, both can be viewed in terms of three roles in materials research efforts at NBS: efficient utilization of materials; environmental measurements, standards and data; and measurements, standards and data for public health and safety. The latter two roles are rather self-explanatory but the first requires a little explanation. When we say "efficient utilization of materials," we mean the proper choice of materials, minimum waste of both materials and energy, and optimum durability and reliability of materials in service.

Materials research is a broad, multi-disciplinary field that relates to many issues of national importance. Indeed, were we to perform all the R&D needed even in the three materials areas mentioned, the Institute would have to be many times larger than it is now. Therefore, current IMR priorities are the result of careful selection. We choose those programs where measurement is the critical factor, where our output—be it a Standard Reference Material, a new measurement method or chemical or physical properties data—appears to have the highest leverage or impact in resolving the problem at hand and in influencing the measurement and research efforts of others. We also try to select areas that have a high research component and that require people to work at their best levels of effort—for it is the intellectual stimulation of a difficult problem which is exciting, and which most often leads to the greatest advances in the field of materials research.

The recognition of the importance of materials and, I believe, of the importance of materials research, is growing. I see this for instance in recent federal regulations which require traceability to NBS Standard Reference Materials, in discussions with the technical public who are increasing their requests for NBS services in materials research, in the passage of legislation assigning specific tasks to NBS in resource conservation and recycling, and in requests for NBS to participate in studies of materials research activities in the public and private sectors. I see no decrease in this interest over the next decade and even beyond. The challenge to us in materials research is to insure the continuing quality of our technical response in the face of this heightened interest and demand.



John D. Hoffman
Director, Institute for Materials Research

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National Bureau of Standards
U.S. Department of Commerce
Volume 61/Number 8

August 1977

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Preserving Stone Art and Architecture

by Stan Lichtenstein

IT is twilight for the gods on the Acropolis. After a sojourn of nearly 2400 years, Kekrops is gone from the Parthenon, and the Erechtheion Maidens will soon follow.

These and other great works of ancient art and architecture are being moved into a museum to save them from destruction in their battle with the environment. Similar problems are faced around the world, but conditions on the plains of Athens provide a startling case in point. After inspecting the Parthenon, three experts from UNESCO concluded that between 1930 and 1970 this temple of Athena had deteriorated more than in all its previous 2350-year history.

The causes of such accelerated damage are many. Carbon dioxide and sulphur pollutants from the area's industries, automobiles, and residences make the rain and dew acidic. The drops dissolve the marble and limestone of the Acropolis, far exceeding the toll nature would take if unabetted. Even some of the efforts to preserve the architecture have proved destructive. Iron used decades ago to support weak structures corroded, and in doing so expanded to cause cracks in the stone.

Currently UNESCO and the Greek government are cooperating to fund a plan that will help, not hinder, restoration. Work is already underway, as in the removal of some of the art works and the production of replicas to replace the originals. (This has also been done in other places, including the exterior of the Strasbourg Cathedral.) Other measures include using a noncorrosive alloy to support weak structures, establishing traffic patterns for the millions of yearly visitors, banning automobiles in the immediate area, and taking other measures to cut down the pollution.

Many of the problems involving the deterioration of the Parthenon and other stone relics require technical solutions. There is no single answer—no panacea. Thus, several approaches must be used in concert.

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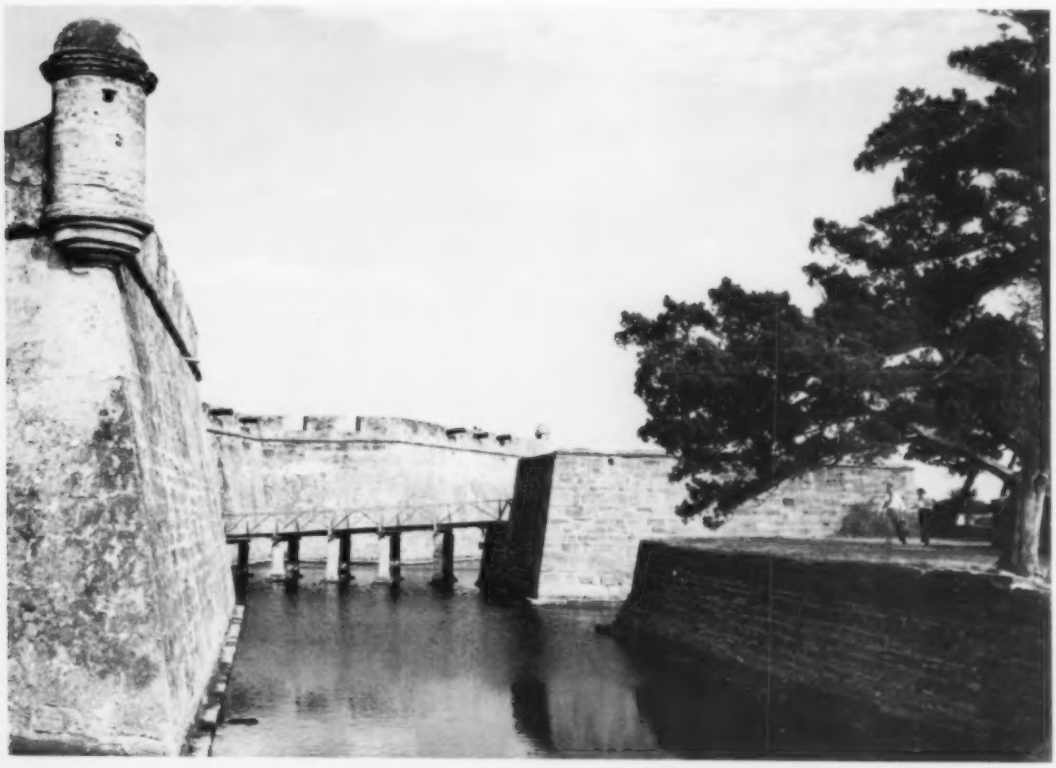
Lichtenstein is a writer and public information specialist in the NBS Office of Information Activities.



Castillo de San Marcos, St. Augustine, Florida. An NBS study on stone preservatives involved field investigations at sites administered by the National Park Service, including this fortress—a Spanish Colonial landmark built by Indians in 1696.

COVER STORY

In theory, one approach could be to apply a protective coating of a transparent material that would act as a barrier between the stone and the environment. Such materials, called stone preservatives, do exist and are in fact proliferating. But there is a lack of information on their long-term performance. Further, just because a preservative is effective at one site does not mean it will prove equally effective at another site where there is a different environment, type of stone, or degree of stone decay.

The uncertainties associated with the use of preservatives have made many stone preservationists reluctant to exploit this option on a large scale. A solid base of knowledge on the subject would enable experts to make informed decisions on whether to include the use of these materials in their plans for preserving a historic stone structure—whether it is the Parthenon or a national monument here at home.

The National Park Service is entrusted with the care of the stonework in some 300 parks and monuments. That agency turned to the National Bureau

Stone architecture in Washington, D.C. This page, clockwise from left: the Capitol, the National Cathedral, a gatepost once located in front of the Capitol. Opposite page, from left: the Jefferson Memorial, the Lincoln Memorial.

of Standards for help in obtaining the missing base of knowledge. Specifically, NBS was asked to investigate preservatives and develop a method the Park Service could use for selecting such materials.

Chemist Gerald Sleater of the NBS research team explains the objective he and his colleagues chose for this project:

"We decided to develop performance criteria for stone preservatives. In other words, we researched the question of how preservatives would have to perform under different conditions, and then we determined how to measure the effectiveness of a material in meeting the requirements."

The researchers recently completed their project, and the results are published in a report called "Stone Preservatives: Methods of Laboratory Testing and Preliminary Performance Criteria."*

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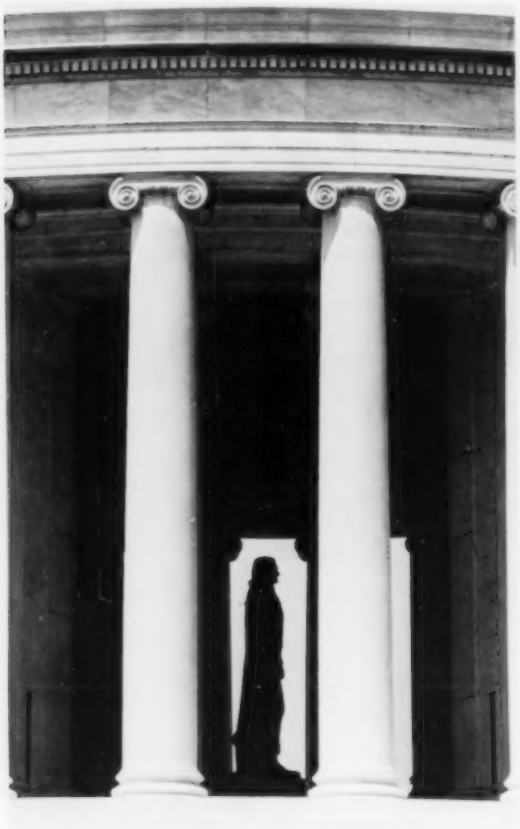
* Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $2.30. Order by stock number 003-003-01727-2.



Left. An experimental wall constructed of over 2000 stones from around the world. Here, a workman prepares the wall for a 40-kilometer trip from the former NBS site in Washington, D.C., to new headquarters in Gaithersburg, Md. It is used by NBS researchers to study natural weathering. Right. Jack Lee of NBS tests a stone specimen in the Chamber for Accelerated Decay.

The National Bureau of Standards, with some 65 years of experience in the area of building technology—including studies on the weathering of building materials—has found that performance criteria serve well for a number of building applications. This is the first time such an approach has been used with stone preservatives.

"Any material that meets the appropriate requirements can then be tried in the field at the local site," says Sleater. He cautions that the preliminary criteria should be used only for the screening of materials. A selected preservative should be tested on-site for at least one year before being used on a full scale, he says, "until the relationship between the criteria and the performance of preservatives in the field is more firmly established."

In carrying out their study, the NBS researchers first conducted a literature survey to find out what was known about stone decay, testing, and preservation and to research the history of the use of stone preservatives. This knowledge was supplemented by field inspections of stone decay problems and preservation efforts at several national monuments.

On the basis of the information they obtained, the scientists selected the performance requirements for stone preservatives (these vary from site to site, depending on external conditions) and identified the tests needed for evaluating performance in the laboratory. Then, the data obtained from the tests became the basis for the preliminary performance criteria—criteria that combine performance requirements and corresponding test methods.

The researchers identified the four main causes of stone decay (apart from structural weaknesses): water action, chemical attack, salt action, and thermal effects such as daily temperature variations that cause expansion and contraction and freezing and thawing of water-saturated stone. According to the NBS report, a person using the performance criteria to select a stone preservative must first determine which of these factors are causing the deterioration he wants to counteract.

The laboratory tests developed by the research team simulate the causes of stone decay, singly or in concert. The scientists ran these tests on sample specimens of stone, using a special apparatus developed by the Illinois Institute of Technology Research Institute. This facility is called a Chamber for Accelerated Decay—or CAD for short.

During one test cycle, the atmosphere within the chamber may be that of sulphuric acid fog. Other possible conditions include salt, ultraviolet radiation, extremes of temperature, condensation, and evaporation—or any combination of these and other conditions that can prevail in the environment.

Indiana limestone (Standard Gray) served as the test stone throughout the studies. This building

material is widely used in the United States and is representative of many stoneworks maintained by Park Service. Further, the properties of Indiana limestone coincided nicely with test program needs: It is susceptible to but not rapidly destroyed by acid attacks such as were used in the chamber; effects of CAD testing on the stone's water absorption, hardness, and other properties were measurable; and the experimental preservatives could penetrate the stone.

A single face of the chamber's specimen drum accommodated 15 uniformly shaped limestone samples—each 10 cm (4 inches) square and 2.5 cm (1 inch) thick. Hundreds of these specimens, both preservative-treated and preservative-untreated, were put through the comprehensive experimental test series in 24-hour cycles that included 8 hours of CAD testing as well as out-of-chamber specimen preparation and testing.

To be considered effective, stone preservatives must meet demanding requirements. In general, they should penetrate the stone and remain there after drying. They should harden the surface against erosion but not visibly encrust the monument, building, or work of art. They should prevent moisture from penetrating, but allow it to escape. They should not discolor or affect the stone's natural look. They should expand and contract uniformly with the stone without flaking. They should be long lasting, harmless and noncorrosive, of reasonable cost, and readily applicable without too many maintenance complications.

Gargoyle on the National Cathedral–an original, not a replica.

Working with Chemist Dr. Gerald Sleater on the NBS programs were Physical Science Aid Jack Lee, Research Chemist Dr. James E. Fearn, and Materials Research Engineer Arthur Hockman. The latter, a 40-year veteran of NBS building research, directed stone-weathering studies in the 1950's when the Bureau erected its own experimental "great wall" on Bureau grounds at Connecticut Avenue and Van Ness Streets in northwest Washington, D.C. The wall—11.6 m (38 ft) long, 3.6 m (12 ft) high and 0.6 m (2 ft) thick—was built of 2032 stones from 47 states and 320 from foreign countries. It is used to study the natural weathering of these materials. (The wall was recently moved to the current NBS headquarters in Gaithersburg, Md.)

Just as the special wall was designed to further a certain "universality" in the experimental approach to problems of stone durability, the study of stone preservatives was conceived and developed to provide broadly applicable findings. Sleater believes the criteria may have to be modified as more information is developed, but they offer three main benefits: They provide an objective basis for selecting stone preservatives, those available now and those that will be developed; they direct attention to properties that stone preservatives should have in order to be effective; and they provide a standard approach which field personnel anywhere in the world can apply to their particular problems. □

Last month in Dimensions/NBS *an article titled "A Primer on Pressure" took an introductory look at the world of pressure measurement. Here at the other end of the scale, Peter Heydemann offers a shopping list of pressure measurements available from NBS.*

Pressure Measurement

by Peter L. Heydemann

THE manometer, which measures pressure or vacuum by the height of a column of fluid, is fairly old; it dates from about 1640. The laser is not; it dates from about 1960.

The old and the new physics will come together in a device presently taking shape in the laboratories of the National Bureau of Standards Pressure and Vacuum Section—a precision mercury manometer that will measure minute changes in the height of the mercury column with the impressive accuracy of a laser interferometer. The new device, which is scheduled to be completed next year, will serve as the primary pressure standard for the range 10^4 to 3×10^5 pascals (0.1 to 3 bars). It will have a resolution of about 10^{-3} pascal, and the expected uncertainty is around 3 parts per million, improving on current standards in that range by an order of magnitude.

I mention the laser interferometer manometer because research and development plays an important part in our program to improve the quality of pressure measurements made and used in American industry and commerce. In recent years, we have studied such things as the mercury melting line from 0 to 700 MPa; dielectric properties of solids as functions of pressure and temperature; ultrasonic interferometers; error estimates for primary pressure standards; nuclear quadrupole resonance at high pressures; and other topics of varying degrees of complexity in efforts to establish a primary pressure scale and improve our primary standards.

Such sophistication loses its value, however, if accurate pressure measurements cannot be transferred to the people who use them in industry and commerce. The second part of our program, therefore, involves a broad range of calibration and measurement services for scientific and industrial users of pressure. Those services, which are a vast improvement over what was available a few years ago, are detailed here.

Transfer Standard Calibration Services

The Pressure and Vacuum Section maintains a group of primary pressure standards covering the range from 10^{-3} to 5×10^8 Pa. The accompanying table provides some detail about the ranges covered by individual instruments, the uncertainties, and the pressure fluids used.

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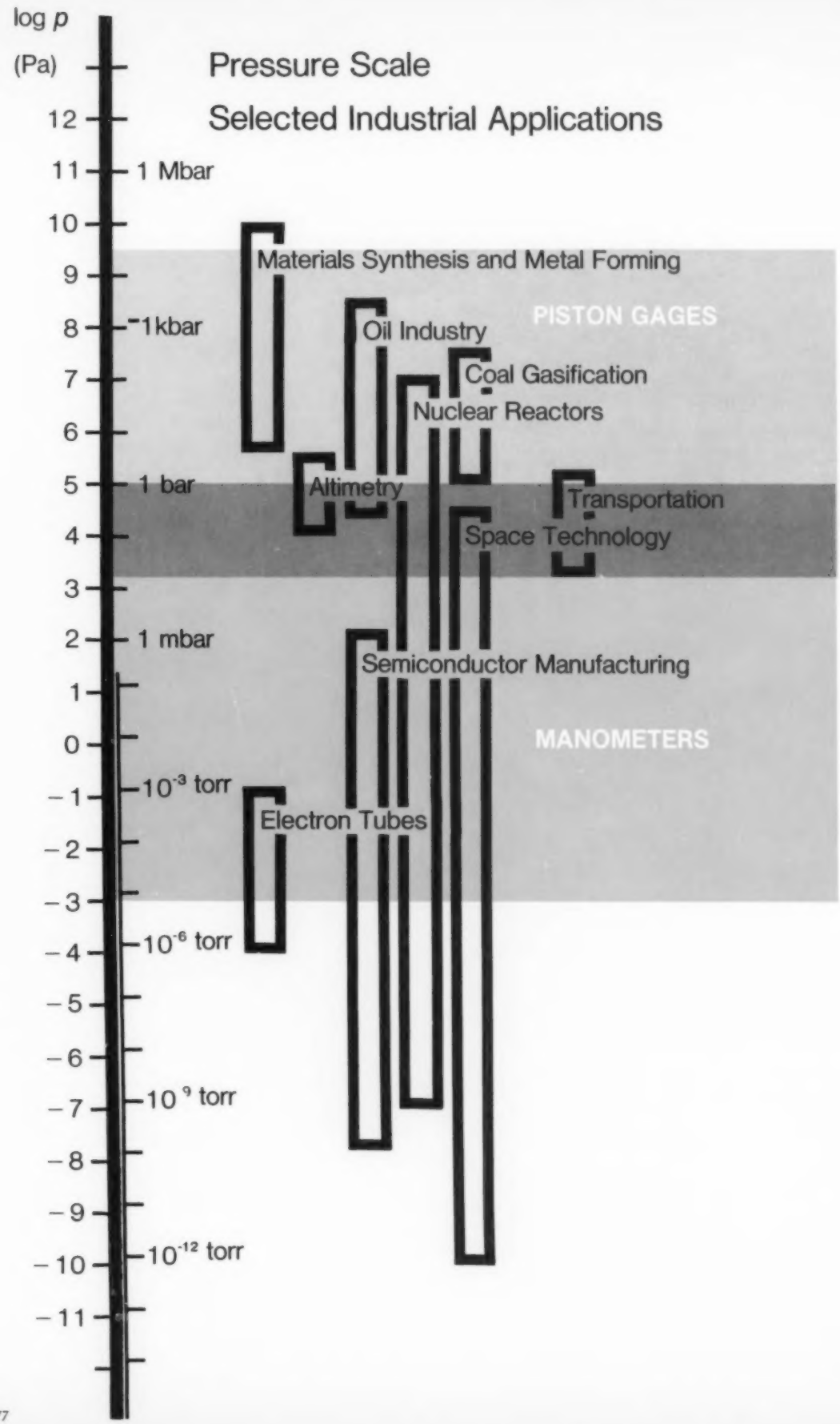
Heydemann is chief of the NBS Pressure and Vacuum Section in the Institute for Basic Standards.


log p
(Pa)
Pressure Scale
Selected Industrial Applications
12
11
1 Mbar
10
9
1kbar
8
7
6
5
1 bar
4
3
2
1 mbar
1
0
−1
−2
−3
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−10
−11
10-3 torr
10-6 torr
10 9 torr
10-12 torr
Materials Synthesis and Metal Forming
PISTON GAGES
Oil Industry
Coal Gasification
Nuclear Reactors
Altimetry
Transportation
Space Technology
Semiconductor Manufacturing
MANOMETERS
Electron Tubes

Controlled clearance piston gages cover a wide and important part of the total range. Their operating principle was developed in a joint effort between D. P. Johnson of NBS and D. H. Newhall of Harwood Engineering. Ultrasonic interferometer manometers are another recent development of this section. With mercury or diffusion pump oil as operating fluid, they cover the low and medium vacuum ranges. The construction of ULTIMA II, the ultrasonic interferometer manometer, allowed the section to expand its vacuum calibration service by over three decades last January, so that the lower limit is now about 1 Pa (0.01 torr). Low vacuum gages up to 10 000 Pa (100 torr) can now be calibrated to an accuracy of 20 mPa plus 0.01 percent of the reading.

All calibrations are carried out by comparing the instrument under test with a standard at a number of different pressures. Five to seven different pressures are needed for the calibration of piston gages. Ten or more different pressures are required for the calibration of transducers and indicating gages. The characteristic coefficients for the devices under test are obtained by fitting suitable functions to the experimental data. The standard deviations of the residuals and of the coefficients are used as measures of the random uncertainty of the calibration operation and of the instrument under test. The systematic uncertainties of the primary standards have been carefully evaluated and must be added to the uncertainty of the instrument under test. The raw data, the results of least-squares fitting a suitable function to the data, the coefficients and standard deviations as well as statements on the random and systematic uncertainties are all included in the Report of Calibration sent to the customer at the end of the test.

Calibrations in the range from 10^{-3} Pa (10^{-5} torr) to 2×10^{5} Pa (1500 torr) will be carried out with manometers, and a variety of gases can be used as pressure transmitting fluids: helium, argon, nitrogen, hydrogen, etc. Either the absolute or the gage mode can be used. Calibrations from 2×10^{3} Pa (0.3 psi) to 4×10^{6} Pa (600 psi) are carried out with pneumatic piston gages, and either dry nitrogen or breathing quality air are used as pressure transmitting fluids. Measurements in the lower part of this range can be made in the absolute or the gage mode. All higher pressure calibrations are made in the gage mode. Calibrations up to 7×10^{8} Pa (100 000 psi) are performed with controlled clearance piston gages. Up to 2.8×10^{8} Pa (40 000 psi) Spinestic 38 and at higher pressures mixtures of Spinestic with heptane are used as pressure transmitting fluids.

Almost any type of pressure gage or transducer can be calibrated against NBS primary standards. Simple piston gages are the instruments most frequently sent to NBS for calibration, because of their proven long term stability. But as more reliable data become available about the long term performance of pressure transducers and gages, more of these types of instruments are submitted to us for calibration.

The cost of calibration is about $500 per instrument per range, but it is slightly higher at pressures above about 7×10^{7} Pa (10 000 psi). Multirange instruments can usually be calibrated for less than $500 per range. The same cost will be incurred for calibrations in the low vacuum range down to 10^{-3} Pa (10^{-5} torr). The time required for a calibration (turn-around time) is generally 60 days. This is occasionally exceeded, but it is also possible to perform an urgently needed calibration within one week or two.

For scheduling and for information about calibrations call Bernard E. Welch at 301/921-2121.

Primary Standard Calibration Services

In our use of the words, "Primary Standards" are instruments capable of measuring pressure without recourse to a calibration against a more accurate pressure standard. Examples of primary standards of pressure are controlled clearance piston gages and certain manometers, where both menisci are accessible for measurement. The calibration of these instruments in terms of the basic units of mass, length and time is often very involved and time consuming. Generally, we believe that a laboratory that elects to have its own primary standards should also be able to calibrate them. Nevertheless, NBS will accept primary standards for calibration. The work needs to be scheduled well in advance and the cost may amount to $3000 or more, because of the relatively large amount of work involved.

Pressure Transducer Characterization Service

There are many good reasons for using pressure transducers as transfer standards, but there is one good reason not to: the lack of reliable data on the long term performance of transducers. To help solve this problem the NBS Pressure and Vacuum Section, in cooperation with industry and users, has developed a set of tests for measuring the long term per-

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Primary Pressure Standards at NBS

Range and Mode* [Pa]	Range [conventional units]	Uncertainty [%]	Transmitting Fluid	Type of Instrument
10^9 to 5×10^9;g	10 to 50 kbar	1	Pentane mixture	Piston and die
7×10^8 to 3×10^9;g	7 to 30 kbar	0.2	Pentane mixture	Controlled Clearance piston gage
4×10^8 to 7×10^8;g	60 000 to 100 000 psi	0.04	Pentane	Hg melting line
3×10^8 to 4×10^8;g	40 000 to 60 000 psi	0.01	Heptane/Spindle oil	Controlled Clearance piston gage
3×10^6 to 3×10^8;g	400 to 40 000 psi	0.006	Spindle oil	Controlled Clearance piston gage
10^5 to 4×10^6;g	15 to 600 psi	0.003	N_2	Controlled Clearance piston gage
10^4 to 2×10^5;a,d	100 to 1500 torr	0.003	N_2,He	Mercury Manometer
2×10^3 to 10^5;a,d	0.3 to 15 psi	0.003	N_2,air	Vacuum backed piston gage
10^{-1} to 10^4;a,d	10^{-3} to 10^2 torr	0.05(tentative)	He, H_2,Ar etc.	Ultrasonic Hg Manometer
10^{-3} to 10^2;a,d	10^{-5} to 0.1 torr	0.1(tentative)	He,H_2,Ar etc.	Ultrasonic Oil Manometer

*modes are denoted by a: absolute, d: differential and g: gage.

formance of transducers. The following parameters are measured in this eight months long test: Warm up, zero drift, supply voltage dependence, calibration, precision, pressure hysteresis, short and long term stability, temperature hysteresis, temperature effects on zero and span, full scale drift, relaxation effects, effects due to pressure cycling, attitude dependence, etc. The test includes several thousand pressure cycles, temperature cycles, loading and unloading tests, numerous calibration runs, etc. At the end of the test an individual, comprehensive report is issued to the submittor for each transducer. The submittors are urged to make these reports available to potential users. With this test we hope to contribute to the knowledge about transducers and to facilitate their use in critical applications.

Test runs begin on October 1st of each year, but potential submittors should contact the Pressure and Vacuum Section well in advance to secure space in the test set-up. The cost is $1,500 for the first transducer and $400 for each additional one of the same type submitted at the same time. For information on the Transducer Characterization Service, contact Dr. Vern Bean 301/921-2121.

Data Evaluation Service

The NBS Pressure and Vacuum Section maintains a number of computer codes for the evaluation of data taken in a variety of calibration operations. Customers can submit their data to us for processing with our computer codes. For this purpose, it is necessary to submit data on NBS Worksheets which are available upon request. This Data Evaluation Service greatly facilitates the processing of data generated during the calibration of controlled clearance piston gages and during the "cross-float" calibration of simple piston gages. The service includes consultations between the customer and NBS staff about the submitted data. We will inspect all runs, check for erroneous data and typing or punching errors, and we will comment on the accuracy of the data and the validity of the conclusions. The cost of this service is quite modest. For details, contact me 301/921-2121.

Consultations

Among the most important services of the NBS Pressure and Vacuum Section are consultations on all matters of pressure measurements. These consultations can be made by telephone, letter or by personal visit with staff members at NBS or at the customer's location. These consultations are generally free of charge. Only the cost of consultations that require a considerable amount of time, as for example, literature searches, will have to be charged to the customer. The range of subjects covered may in any one day range from the operation of a capuccini machine to the calculation of the uncertainty at the end of a calibration chain, or from the request for data on the vapor pressure of a pump oil to information on ultrasonic measurements at 5 GPa (50 kbar). Consultations are important also for the Pressure and Vacuum Section because they help to establish contacts with people in the field, they help us to understand problems encountered in industry and often they point to areas where NBS should get involved. We are prepared to help with the planning of pressure standards laboratories, writing of manuals, procedures, documentary standards etc. For details call me at 301/921-2121.

Training

Several years ago, the Pressure and Vacuum Section began to offer training courses in pressure measurements for people from industrial standards laboratories. These courses are offered several times a year. The number of participants is limited in order to give each participant the fullest possible attention. Depending on the interest of the participants, the emphasis may be more on the primary or on the secondary standard calibrations.

The training courses are held at the NBS site in Gaithersburg, Maryland, near Washington, D.C., and take two days to complete. For scheduling and information, call Mrs. Carol Thomas at 301/921-2121.

Focal Point

The field of pressure measurements is distinguished from any other field of metrology by the tremendous range of pressures measured and by the equally wide range of applications for which it is important. At the same time, the field suffers from the lack of an accepted and acceptable scale analogous to the temperature scale represented by the platinum resistance thermometer and from the lack of structure. We think that the Pressure and Vacuum Section can be a useful focal point in improving the pressure measurement system, and we urge industrial and scientific interests to make use of our services. □

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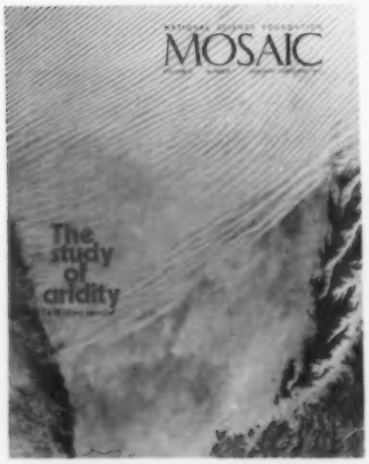

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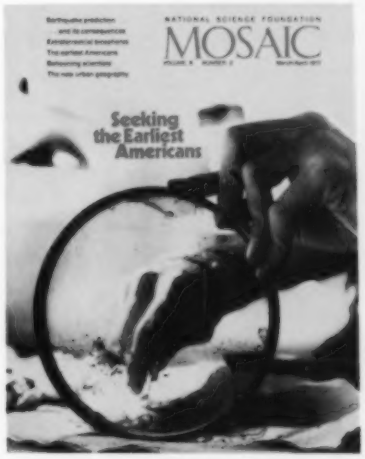

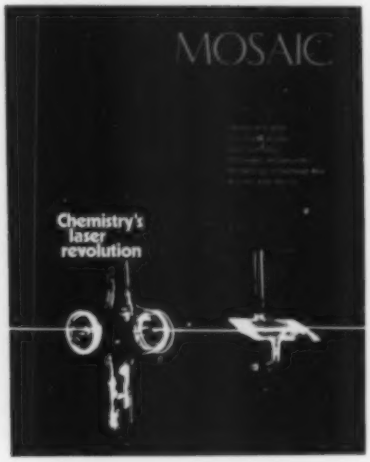

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Profile of an Inventor:

Marzetta in the laboratory working to improve the energy efficiency of home appliances.

by Frederick P. McGehan

Some individuals excel in inventiveness. In the right kind of environment, they can use their abilities to benefit many people. Louis Marzetta is a man with ingenuity who has found an outlet for his talent at the National Bureau of Standards. The Bureau helped to shape Marzetta's career as an inventor. Marzetta's inventiveness, in turn, has improved safety in American homes.

RESEARCH is carried out at the National Bureau of Standards on all levels, from the esoteric to the mundane. This has been true since the Bureau was established, but within the past two decades, a new wrinkle has developed. Congress has been demanding that more research be directed toward areas of public concern like safety and health.

This new emphasis has been reflected at NBS in many ways, including the creation of the Institute for Applied Technology (IAT) in 1964. It has also altered the careers of some members of the NBS staff. Louis Marzetta, a soft-spoken electrical engineer, is one.

Marzetta came to the Bureau in 1948 from the Naval Research Laboratory where he started in 1942 as a technician with time out for service in the Navy during World War II. Shortly after coming to NBS, the Hopedale, Massachusetts, native obtained a degree in electrical engineering from the University of Maryland, took the state examination and became a registered professional engineer.

For much of his career at the Bureau, Marzetta devoted himself to precision measurement and electronic instrumentation. But in 1972, at a precision measurement conference in Boulder, Colorado, Marzetta heard Dr. F. Karl Willenbrock, newly appointed director of IAT, say that there would be some change in orientation at IAT as the result of new legislation.

A short while later, Marzetta had lunch with Willenbrock, and the new director offered him a challenge. "He said 'How would you like to study an appliance—from an engineer's point of view for safety and efficiency,'" Marzetta recalled in a recent interview.

Marzetta accepted the challenge and, after some thought, selected the ordinary household toaster because, as he put it, "the toaster had certain

McGehan, formerly a writer and information specialist in the NBS Office of Information Activities, is now with the NBS Program Information Office in Boulder, CO.

Louis Marzetta

features that were hazardous." These hazards included exposed wires and high surface temperatures.

"It turned out to be an interesting study. It resulted in what I call the 'NBS toaster,' a hazard-free device," Marzetta remarked.

"During the first few weeks I was on the project, a youngster in Arlington, Virginia, was electrocuted when he put his hand in a toaster slot," Marzetta recalled.

The toaster study proved to be of further value when the Consumer Product Safety Commission (CPSC), formed in 1973, came to NBS for the development of an instrument to test burn hazards of hot surfaces.

In his toaster work, Marzetta had discovered that the human finger is a poor thermometer. It responds more to heat flow than to surface temperature. This is why in many instances a person can touch the plastic knob of a hot pot without getting a burn, but will get burned if he touches the metal cover. While the two materials may be at the same temperature, the plastic conducts heat at a much slower rate than metal.

The result of Marzetta's work was his invention of the thermesthesiometer, a probe that simulates the response of the human finger to hot surfaces. The probe has been manufactured by a commercial firm and is being used by the CPSC to inspect appliances and by manufacturers to design their products.

Marzetta was awarded a patent for the thermesthesiometer and also recently another patent for his concept of "cool touch" cooking surfaces. Although he has not developed a working model, he has found—theoretically at least—that the surfaces of warming trays, hot plates and, perhaps, smooth-top kitchen ranges could be covered with a substance that would permit brief human contact and at the same time perform the warming and cooking tasks.

Currently, Marzetta is applying his electrical engineering talents in a study of home clothes dryers, seeking to determine ways in which the dryers can utilize energy more efficiently. It appears that a 6 percent saving in energy used in clothes dryers is technically feasible. Considering there are more than 30 million dryers in use, at an average energy cost of $60 per year (for electrically-operated dryers), the potential saving is more than $100 million a year in energy costs when all dryers are eventually replaced.

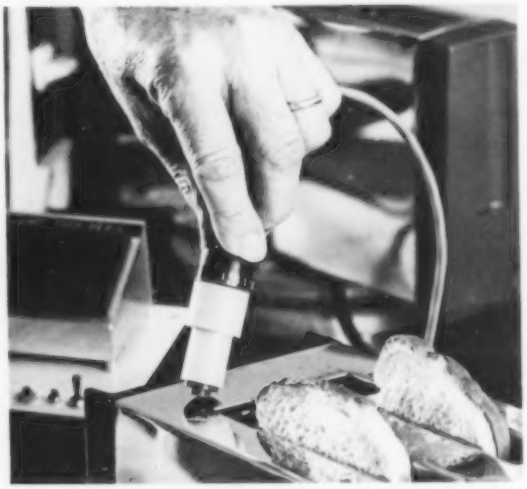
Marzetta does not necessarily see himself as a champion of the consumer—although his work will have great impact on the safety of some consumer products, and, potentially, relieve some of the burden on consumer pocketbooks. He views himself more as an engineer who enjoys a technical challenge.

"If a technical problem exists with a device, it should be solvable with good engineering practices. Technology causes problems, but it can also solve them," he emphasizes.

He also sees his profession and career in a context of evolution: "I agree with the thought that everything obeys laws of evolution—including the economy, society, and technology."

Although 30 years ago it was perfectly acceptable for NBS to remain somewhat detached, "cloistered" as Marzetta phrases it, the demands of today call for NBS to participate more fully in solving society's technological problems.

"We can contribute. All technical people have an obligation to develop an enthusiasm for this type of work," Marzetta states, adding: "I like to know we're contributing to the public welfare and safety." □



This heat-sensing probe is used in designing and testing products for safety from burn hazards.

Home Security Alarms

What They Are and How They Work

WITH the increasing rate of residential burglary, homeowners are becoming more and more concerned for the security of their homes and personal belongings. A solidly constructed door, hung on a well-fitted frame and secured with a good deadbolt lock, along with windows that will resist forced entry, should offer adequate protection for your home. However, for additional protection, many homeowners are considering the installation of home security alarm systems.

How do alarm systems work?

All security alarms are made up of three basic parts: the detectors or sensors, the control unit, and the actual alarm. The detectors or sensors are electronic or electromagnetic devices that act as observers by detecting the presence or action of an intruder.

The control unit is the heart of the system, to which all sensors are connected. The unit receives the information that a sensor has been disturbed and transmits a signal that triggers the alarm. Devices called "panic buttons" can also be connected to the control unit. These devices allow you to activate the alarm manually and are usually placed at the front door or in the bedroom.

The alarm reports that a sensor has been disturbed. It can sound at your home, or the signal can be transmitted to a remote location.

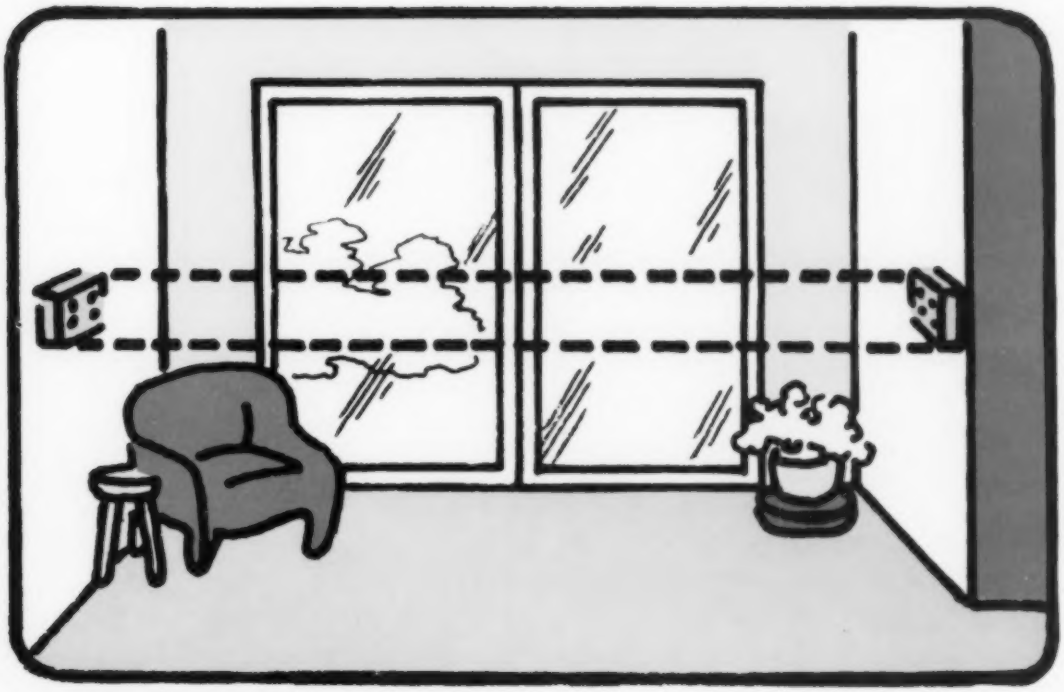
How do the detectors or sensors work?

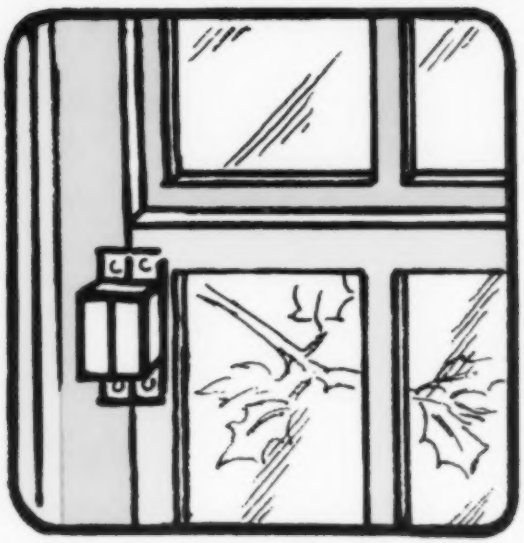
The following are some of the more commonly available sensors or detectors:

Switch sensors are electromagnetic devices that are installed at all entry points considered to be accessible from the ground. When a door or window is opened, the alarm is triggered. It is advisable to install sensors on all windows or balcony doors that are adjacent to trees. Switch sensors are the most frequently used alarm sensors in residences.

Pressure mats are used to protect specific areas of the home. The mats can be hidden under a carpet or rug in a frequently traveled corridor or can be used near items of value such as your TV set or stereo system. When pressure is exerted on the mat, the alarm is triggered.

Ultrasonic motion detectors fill the room with sound waves too high for most humans to hear. Any movement in the room disturbs the wave pattern and triggers the alarm. As some people and most animals are bothered by the high-pitched sounds, an in-home demonstration before purchasing is advisable.





Infrared photoelectric sensors project an infrared light beam between two points. Anything interrupting the beam will trigger an alarm. They are effective when installed at entry points as well as specific areas inside your home.

How are the sensors and "panic buttons" connected to the control unit?

The sensors and panic buttons can be connected to the control unit either by direct wiring or by a wireless system.

The wireless system operates on batteries that must be changed periodically. Transmitters are installed at each sensor or panic button and a receiver is installed in the control unit. The wireless panic button can be carried from room to room. Wired and wireless systems are equally effective.

How does the alarm report an intrusion?

There are two types of reporting alarms available—local and remote.

The *local* alarm is the simplest to install and the least expensive. When the system detects an intruder the alarm signal is heard at or near your home. Its effectiveness depends on the intruder being frightened away, or neighbors calling the police. The alarm device is generally located in the attic or under the eaves of the roof.

The *remote* alarm transmits the alarm signal to a location away from your home, but can be combined with a local alarm. Several types of remote alarms are available;

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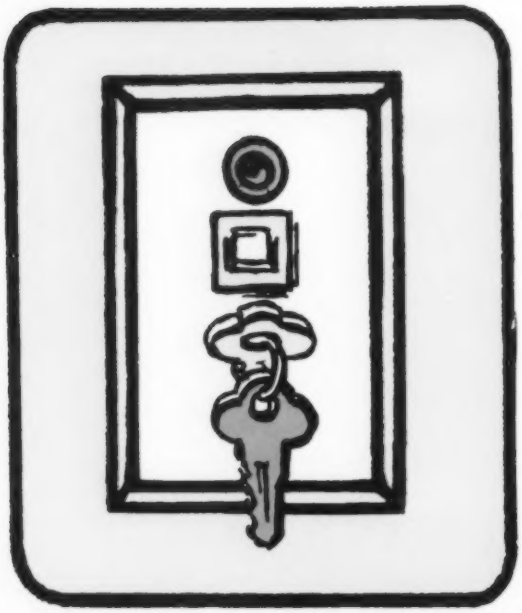


The automatic dialer sends a prerecorded message or signal over telephone lines to a person you choose: an answering service, a neighbor, or a relative. The effectiveness of this system depends on someone being present to answer the telephone and call the police. The telephone company requires that the installation of a dialer system meet its specifications. *Do not* direct your alarm to the local police department without its prior approval. Several of the first dialer alarms were so unreliable that many jurisdictions continue to prohibit directing an alarm from a dialer to a police department.

- The direct-connect system transmits the alarm signal to the police department. This type of service provides very good protection, but often is not available to the private home owner. Many jurisdictions limit the direct-connect service to financial institutions and commercial establishments. The signals are transmitted over leased lines and there is a monthly charge to the subscriber.
- The central station system is a commercial service. The alarm signal is transmitted to a private security company that monitors the system. In addition to notifying the police that your system has sent an alarm, the central station will dispatch guards to your home. Central stations will normally include the maintenance and repair of your alarm system as a part of your contract and will charge a monthly service fee.

What is the cost of an alarm system?

The cost of purchasing and installing a system can range from several hundred dollars to more than a thousand dollars. In addition, a monthly service fee of from ten to more than fifty dollars may be charged for some remote alarm systems.

How can I be sure my system is a quality product?

Your security alarm should be approved by a major testing laboratory, such as Underwriters' Laboratories, Inc. (UL).

How can I get the best service from my alarm system?

To get the best service from your alarm system, establish and follow a routine. When activating the system, make sure that doors and windows are closed and that pets are removed from protected areas. Nine out of ten alarms transmitted are false, half of which are caused by improper operation.

Do not treat the system like a new toy or demonstrate it to your friends. If your system sends alarms unnecessarily, it will lose credibility.

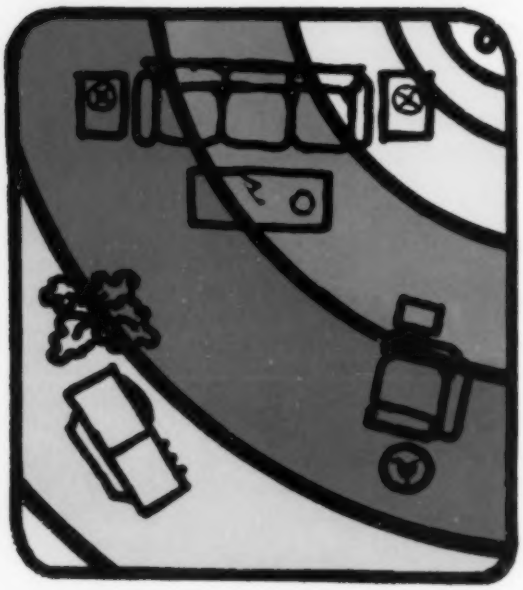
Improperly selected or installed sensors can also cause false alarms. For example, some sensors may react to changes in temperature or humidity, or to a draft from heating and air conditioning vents. Similarly, the motion of a billowing curtain or a ringing telephone bell may cause an ultrasonic motion detector to signal an alarm. In addition, your system should not be operated on the same electrical circuit as kitchen appliances or your heating and cooling system. The cyclic operation of these appliances may trigger an alarm. Your installer can advise you on the selection and placement of sensors that will best suit your needs.

Some detectors have sensitivity adjustments. Do not set them too high; they could become an almost constant source of false alarms. Also, do not try to increase the area of protection of a detector by increasing its sensitivity. Either use two detectors, or buy one that will meet your needs.

What else should I know about purchasing an alarm system?

Local laws. The system you purchase should conform to local ordinances. Make sure to check the local laws regarding noise (some jurisdictions limit the time that an alarm can sound) and licensing of installers. Get price quotations from several companies before you install your system; costs for equipment and installation will vary.

Installation. Discuss installation and maintenance with the installer before you sign a contract. Know



how the system will be installed. Will the wiring be concealed or exposed? Will touchup painting be needed when the installation is complete? Ask to see how the sensors will look—you may find their appearance unacceptable. The more you know before you sign a contract, the better.

Optional features. There are a few optional features that you may want to consider adding to your system: 1. a key-activated switch that allows you to turn the system on and off from the outside; 2. a test switch that allows you to check all sensors without sending an alarm; and 3. battery-powered back-up that allows the system to continue to operate during a power failure.

Maintenance. Once the system is installed, follow the manufacturer's instructions carefully, and be sure that all the members of your family know how to operate the system.

What should I do if the alarm goes off?

When an intruder hears the alarm, his primary interest is getting out of the house as quickly as possible. If you are in the house, *stay out of the way.* If you can, lock yourself in your bedroom. The intruder is more likely to hurt you if confronted. Telephone the police as soon as possible.

*This article is a reprint of a pamphlet by this title. The information is based on research performed by the Law Enforcement Standards Laboratory, Institute for Applied Technology, National Bureau of Standards, under the sponsorship of the National Institute for Law Enforcement and Criminal Justice, U.S. Department of Justice.

For more information on home security write: Home Security Starts At Your Door, Consumer Information Center, Pueblo, Colorado 81009. □

ON LINE WITH INDUSTRY

NBS/ASTM RESEARCH ASSOCIATE PROGRAM DEVELOPS URGENTLY NEEDED SRM'S

With the current interest in environment, health, and energy, the resources of the National Bureau of Standards' Office of Standard Reference Materials (OSRM) have been heavily concentrated on developing critically needed new Standard Reference Materials (SRM's) for use in these national concern areas. Consequently, NBS has looked for alternative mechanisms to support the more traditional task of developing SRM's used in industry for control.

A research associate program sponsored by the American Society for Testing and Materials (ASTM) is providing some of this support. The objective of the NBS/ASTM venture, begun in January 1976, is to maintain the availability of current metals - related SRM's and to develop new SRM's for use in industrial laboratories.

SRM's are materials for which the chemical composition, or particular chemical or physical properties, have been accurately determined and certified. They are used throughout industry and the scientific community to calibrate and evaluate measurement instruments and systems and test methods.

Since its inception, the NBS/ASTM program has accelerated the issuance of 12 essential SRM's, including those for cast iron, burnt refractories, various steels, and an iron core. Most of the certification data for these materials were obtained through networks of industrial and commercial laboratories. Twenty eight SRM's are now being prepared through this cooperative program, and an additional 38 SRM's are in the planning stage. For example, a series of SRM's for impurity elements in pig lead are in the development stage to promote quality assurance in the production of new "lifetime" batteries for automobiles, says Robert Michaelis, Chief Standards Coordinator of the Office of Standard Reference Materials and supervisor of the ASTM research associate program.

The program is supported by the contributions of approximately 50 companies representing a broad spectrum of producers and consumers of metals and related materials. The industrial input to the program is directed through the ASTM Coordinating Committee for Standard Reference Materials. This Committee, designated S-17, was formed by ASTM Committees E-2 on Emission Spectroscopy, E-3 on Chemical Analysis of Metals, and E-16 on Sampling and Analysis of Metal Bearing Ores and Related Materials. These committees represent most of the metals industries. Committee S-17 rates the needed SRM's in order of highest priority, and these are the ones developed by the NBS/ASTM program.

"We are pleased that the SRM's are meeting the committees' needs," says Earl Sullivan of ASTM. "There is great satisfaction in knowing the SRM's are being provided on a timely basis that otherwise would not have been possible. The program is working out in an excellent manner and we trust it will continue indefinitely."

To fill the research associate position, ASTM selected James I. Shultz and, later, Rosemond K. Bell, as assistant research associate. Both are former NBS employees. Prior to his retirement from NBS where he had worked for over 30 years, Shultz held the dual role of SRM Coordinator for the Analytical Chemistry Division and assistant section chief for the Analytical Coordination Chemistry Section. Mr. Shultz has been a member of ASTM and its technical Committee on Chemical Analysis of Metal for 17 years. Bell worked at NBS for more than 45 years and has made outstanding contributions in the field of analysis of non-ferrous alloys. He has been an active member of ASTM Committee E-3 since 1946.

The success of the program in developing SRM's for the metal industries has spurred interest in SRM's in general by other industries that are members of ASTM in starting research associate projects, according to Sullivan. "We are currently working with the NBS office in order to set up a workshop in November that will explore the possibility of starting research programs to develop SRM's in other areas, such as rubber and glass."

The NBS/ASTM program has shown that when there is a strong need for an SRM it can be fulfilled by cooperation between government and industry, comments Sullivan.

STANDARDSTATUS

SHEDDING MORE LIGHT ON THE ULTRAVIOLET

by Michael Baum

Up until a few years ago, ultraviolet light was a fairly uninteresting topic to most people, even most scientists, but it's not being ignored any longer. A few of the reasons:

Some of the ultraviolet (UV) in solar radiation is carcinogenic. It has been estimated that natural sunlight causes about 300,000 new cases of skin cancer, and about 6000 deaths from the disease. in the U.S. every year.

Ultraviolet radiation is being used increasingly in industry—in accelerated weathering machines, in manufacturing microelectronic components, and even in canneries to dry the ink imprinted on beverage cans. Last year more than one-half billion dollars was spent on such processes, and the figure increases about 30 percent each year.

In the medical field, UV is being used more and more in the treatment and therapy for common diseases such as psoriasis, as well as in dentistry to cure new enamel.

With the growing interest in the ultraviolet spectrum, we are learning some disquieting things about our ability to accurately measure this radiation. A good example is the case of fluorocarbons and the stratosphere's ozone shield. The reason for current worries that fluorocarbons and other pollutants are breaking down the ozone in the planet's upper atmosphere is that the ozone filters out a good deal of harmful ultraviolet radiation in the so-called UV-B range (wavelengths from about 280-320 nm). An increase in the amount of UV-B that reaches the Earth's surface can affect not only human health, but, by changing the global heat balance, agriculture and animal life as well.

Meaningful studies of these effects will require field measurements of UV radiation with an accuracy of at least 2 percent over the 11-year solar cycle. The uncertainty for such field measurements now is about 16 percent, and only in the highest quality standardization laboratories, under good conditions, can measurements of UV irradiance be made with an accuracy of 2 percent.

Similar accuracy is needed where ultraviolet radiation is being used in medical and industrial applications. What range of wavelengths is most effective for the purpose at hand with the minimum number of side effects? If regulations are to be written to protect workers and patients from excess exposure to UV radiation, what is the maximum permissible exposure rate for any particular wavelength?

The answers to questions like these generally involve measuring very complex forms of radiation, where the radiation changes rapidly with wavelength, where there is interference from the more intense, longer wavelengths of light, and where the standards are often less accurate than those for visible light.

A recent study by researchers at the National Bureau of Standards characterized the major spectroradiometers that are available for UV measurements. They found the current "state of the art" for the UV measurements to vary between about 3 percent error for laboratory measurements of simple radiation to as much as 24 percent error for field measurements under very adverse conditions.

NBS is working in a number of areas to improve this "state of the art." A recent addition to the calibration technology is the argon "mini-arc" light source, which is now commercially available. Designed as a *convenient* secondary *radiance* standard, the argon source is accurate to about 6 percent between 140-330 nm and to about 15 percent between 115 and 140 nm when calibrated against the NBS primary standard.

The argon lamp extends the range of NBS deuterium lamp which also serves as a radiance source for the region from 165-350 nm, and which, using the argon mini-arc, can now be calibrated as a spectral irradiance standard in the 200-350 nm range.

Silicon detectors are being developed as spectral response transfer standards, and should be available later this year. The calibration packages should be accurate to the 1 percent level in the region around 257 nm. In the vacuum ultraviolet and extreme ultraviolet ranges, the Bureau's Synchrotron Ultraviolet Radiation Facility (SURF) offers instrument calibration services and transfers standard detectors for the range between 5 and 330 nm.

To disseminate accurate measurements to the field, the results of the NBS study of spectroradiometers are being analysed and means for improving the instruments are being evaluated. A diagnostic standard for the UV-B region has been developed in the form of a calibrated fluorescent lamp which can be used to assess the performance of spectroradiometers in this region. NBS is also publishing a series of Technical Notes, collectively entitled "Self-Study Manual on Optical Radiation Measurements" which present in detail the steps necessary to reach "state of the art" accuracy in this field.

Baum is a writer and public information specialist in the NBS Office of Information Activities.

STAFF REPORTS

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MOLECULAR IDENTITY OF POWER PLANT STACK PARTICULATES

Research conducted at NBS with a unique Raman microprobe provides insight into the molecular identity of particulate emissions from oil-fired power plants. Stack effluents were sampled directly onto sapphire substrates for Raman spectroscopic analysis. Raman spectra observed from single microcrystals formed on the collection surface show V_2O_5 as a principal molecular constitutent. From this we infer the existence of vanadium pentoxide as a major component of the stack emissions. These results are important to determining the chemical states of toxic elements in airborne particles and complement in a significant way the data on the elemental composition of fly ash particles obtained by other microprobe techniques.

Edgar S. Etz, Analytical Chemistry Division, A115 Chemistry Building, 301/921-2862, and Gregory S. Rosasco, Inorganic Materials Division, A165 Materials Building, 301/921-2780.

To assess the effect of pollutant particles from power plants on man and the environment, more information is needed on the composition of fly ash. Existing data on the chemical properties of fly ash are largely limited to the *elemental* composition of bulk samples of particulates collected in the stack and in the plume of power plants. Frequently the elemental concentrations are correlated with the physical properties, primarily the size fractions, of such samples. Modern analytical microprobe methods utilizing electron and ion beams have been applied in a number of studies to determine both major and minor elements in single fly ash particles of micrometer size, but it is difficult to infer from these results the *molecular* composition of fly ash particles.

We reported a year ago (NBS DIMENSIONS, May 1976) on the development at NBS of a unique laser-Raman microprobe designed to enable the spectroscopic analysis of microparticles. In this new instrument, single particles—supported by a suitable substrate—are moved into the focal point of a laser beam (utilizing any one of several "excitation" frequencies in the visible region of the spectrum) and the light scattered by the sample is analyzed for its spectral content. The scattered light contains the Raman spectrum of the particle which is diagnostic of molecular and crystal vibrations in the solid. Particles composed of a broad range of inorganic compounds, organic solids, and polymers show the normal Raman effect and can therefore be identified as to principal molecular constituents. The application of Raman spectroscopy to single particle analysis thereby offers the opportunity for the chemical speciation of major elements and provides a new insight into the microscopic domain unattainable by other microprobes.

The new instrument and technique have since been applied to molecular microprobing of individual particles in diverse types of environmental samples. These studies have included the characterization of particulate emissions from oil-fired power plants. The samples analyzed were collected by the Environmental Protection Agency with size-fractionating cascade impactors modified to accommodate particle collection substrates (fabricated from optical-quality sapphire) suitable for Raman microanalysis.

The power plant monitored was one burning a fuel of relatively high sulfur (about 2.5 wt. percent) and trace element (e.g., approx. 400 ppm V) content. Particle sampling was conducted isokinetically out-of-stack at a sampling port where the stack temperature was 164 °C. In a typical collection of the particulate emissions, a 5-stage impactor was employed using sampling times that would furnish deposits of low particle density, thereby minimizing extensive agglomeration of particulates.

Representative of these multi-particle deposits on sapphire (α-Al_2O_3) substrates is the collection of particles shown in the optical micrograph (at 125×) of figure 1. The field of view contains the various types of solid particulates found on the fourth impaction stage. Variations in the size, shape and morphology are readily apparent. Observation in the light microscope also shows wide variations in optical properties (e.g., color), with microcrystals of dendritic morphology showing colors from brown to yellow-green and particles of globular shape exhibiting similar colors in a generally colorless, transparent matrix interspersed with bits of black, opaque material.

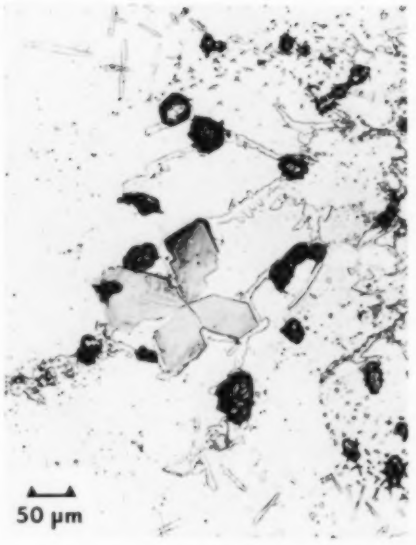


Figure 1—Microscopic View (Magnification 125X) of Power Plant Stack Particulates Collected on a Sapphire Substrate.
Emissions found on the fourth stage of a five-stage impaction sampler.

The vast majority of the particulates on this and on the other stages of the sampler are too large to be accounted for by the size cut-off characteristics of each stage. This implies that much of the material seen in the micrograph has formed on the collection surface through the interaction of solid/liquid microparticles with other components of the gas/vapor phase of the sampled stack aerosol. Our observations of the particulate material collected on the other stages similarly attest to the reactive (and corrosive) na-

ture of the stack emissions.

Application of the NBS Raman microprobe to the characterization of these samples has now furnished unique results which demonstrate the usefulness of the technique and its significance to studies where other microprobes are capable of yielding elemental composition data. An important objective of these and related studies is the speciation of toxic elements. We have obtained Raman spectra from particles in samples described above. These spectra provide a unique fingerprint of major molecular constituents and also reveal the crystalline or glassy state of the particle. Typical of the results from particles with dendritic morphology is the spectrum shown in figure 2, obtained from probing a small area (commensurate with size of beam spot) of the large, four-leaf microcrystal (compare with fig. 1). The predominant features in the spectrum are bands with Raman shifts around 145, 280 and 1000 cm^{-1}. Taken together these are characteristic of vanadium pentoxide, V_2O_5. To verify the existence of V_2O_5 in particles of this type, we have studied pure, crystalline V_2O_5 and obtained its spectrum from a particle approximately 5 μm in size. This result is shown in figure 3. Qualitative comparison of the spectrum of the unknown crystal with that of the known particle shows good agreement, except for several medium-intensity bands in the region 820 to 970 cm^{-1} which are absent in pure V_2O_5. These additional bands are due to the presence of a second component, so far unidentified. These same features, however, are absent in the spectra of numerous other brown, dendritic microcrystals (of sizes down to 5 μm) whose spectra are identical to that shown for V_2O_5.

Other types of particles in this sample have yielded spectra characteristic of other compounds. The particles of globular shape (see figure 1) exhibit spectra indicating the presence of crystalline sulfate, and work continues on the identification of these solids as to the associated cation species. Many of the spectra also show bands characteristic of a form of polycrystalline graphite. We believe that these bands derive either from combustion-produced carbon (e.g., soot) or from residual hydrocarbon matter associated with the particles. They are also seen in the spectra of urban air particulates indicating the widespread existence of one or more forms of environmental carbon with airborne particles from a variety of sources.

The results obtained with the Raman microprobe are of significance, for example, to the assessment of the toxicological hazards associated with the particulate emissions from power plants. Future work in our laboratory will be directed toward the study of chemical species in the plume and their likely transformation on transport in the atmosphere.

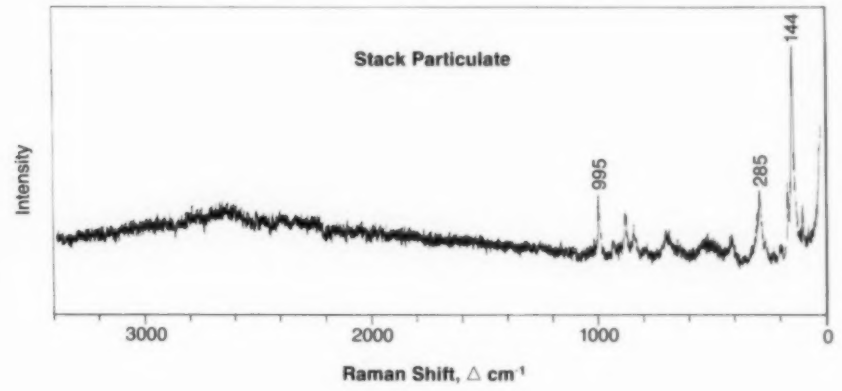


Figure 2—Raman Spectrum Recorded from Probing a Small Region of the Large, Four-Leaf Microcrystal Shown in figure 1.
Measurement parameters: substrate, α-Al_2O_3; laser, $\lambda_o = 514.5$ nm; power 60 mW (at sample); beam spot, ~ 7 μm diameter; spectral slit width, 3 cm^{-1}; time constant, 0.8 second; scan rate, 50 cm^{-1} per minute; intensity, 10^5 counts full scale.

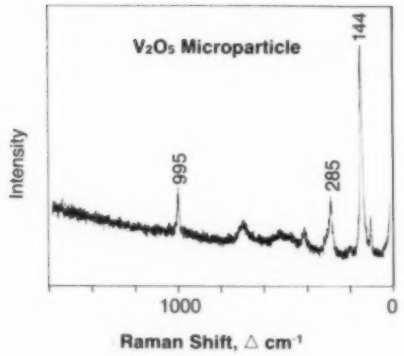


Figure 3—Raman Spectrum of a Microparticle of Crystalline Vanadium Pentoxide (V_2O_5).
Measurement parameters: particle size 4 × 5 μm; substrate LiF; laser, $\lambda_o = 514.5$ nm; power, 3 mW (at sample); beam spot, ~ 13 μm diameter; spectral slit width, 3 cm^{-1}; time constant, 1.6 second; scan rate, 20 cm^{-1} per minute; intensity, 10^3 counts full scale.

TECHNOLOGY ASSESSMENT OF COMPUTER MEMORIES

Discrete and mechanical peripheral memory systems for computers could soon be replaced by solid-state memories, with the possible major exception of the videodisk system. This is one of the conclusions reached by researchers at NBS who are conducting a technology assessment of computer memory systems.

Robert B. J. Warnar, Information Technology Division (ITD), B242 Technology Building, 301/921-3518, and Peter J. Calomeris, ITD, B240 Technology Building, 301/921-3414.

In the course of assessing computer memories, we observe that since the development of the first computer systems, three significant memory technologies have evolved: magnetic, electronic, and optical. Although these technologies were originally designed with either discrete components (such as cores) or with mechanical, moving parts, (disks, drums, etc.), trends now indicate that many of these memories can soon be replaced with solid-state counterparts such as charge-coupled or magnetic bubble devices (see Table 1).

We suggest that this substitution is warranted in many applications since solid-state device characteristics are vastly superior to most conventional mechanical memories (see Table 1). Solid-state memories can present, or access, their data five orders of magnitude faster, send out their data more than one order faster, operate at two orders less power, and can be packaged in one order less space. Many solid-state parameters are being

Table 1—A Comparison of Various Memory Characteristics

(1977 Data) Memory Technology	Average Capacity -Unformatted- (Kilobits)	Data Rate (Bits per Second)	Average Access Time (milliseconds)	Price Per Bit (Cents)	Random Access	Nonvolatile	Medium Concept
Drums (Fixed head, first drive)	1.0×10^{5}	6.0×10^{6}	8.5	2.0×10^{-2}	Block* Access	Yes	Mechanical
Tapes (Mass storage system)	1.1×10^{9}	1.2×10^{6} (Bytes per second)	1.4×10^{4}	2.5×10^{-5}	No	Yes	Mechanical
Cores (Single module)	6.4×10^{2}	2.0×10^{6}	2.5×10^{-4}	1.9×10^{-1}	Yes	Yes	Discrete
Disks (Moving head, first drive)	6.0×10^{5}	1.2×10^{6} (Bytes per second)	3.7×10^{1}	7.7×10^{-4}	Block* Access	Yes	Mechanical
Cartridge (one) (Single drive with electronics)	2.4×10^{4}	4.8×10^{4}	2.0×10^{4}	1.0×10^{-2}	No	Yes	Mechanical
Cassette (one) (Single drive with electronics)	5.8×10^{3}	2.4×10^{4}	2.0×10^{4}	1.3×10^{-2}	No	Yes	Mechanical
Bipolar Random Access Memory (per chip)	4.0	1.3×10^{7}	6.0×10^{-5}	5.0×10^{-1}	Yes	No	Solid-State
Metal-Oxide-Semiconductor (MOS) (per chip)	1.6×10^{1}	2.0×10^{6}	2.7×10^{-4}	3.0×10^{-1}	Yes	Few	Solid-State
Floppy Disk (one) (Single drive with electronics, double density)	6.4×10^{3}	5.0×10^{5}	2.6×10^{2}	1.0×10^{-2}	Block* Access	Yes	Mechanical
Magnetic Bubbles (per chip)	1.0×10^{2}	5.0×10^{4}	4.0	1.1×10^{-1}	Block* Access	Yes	Solid-State
Charge-coupled Devices (per chip)	1.6×10^{1}	2.0×10^{6}	6.5×10^{-2}	1.3×10^{-1}	Block* Access	Few	Solid-State
Video Disks** (Read-only-memory, single disk medium)	1.0×10^{7}	7.2×10^{6}	5.0×10^{3}	1.0×10^{-5}	Block* Access	Yes	Mechanical

* Random access to serial blocks of information ** Near-term projected figures for large quantities

optimized by a factor of 2 each year.

However, mechanical, rotating memories are as yet more economical to use in many applications, which prevents the emergence of total solid-state supercomputer systems. (Small-scale solid-state computer systems, on a single chip with built-in high-capacity memories —up to 32 kilobits—shoud be available within 2 to 3 years.)

The ever-increasing demands of the memory users for larger, faster, and cheaper memory systems have caused memory manufacturers to resort to extremely sophisticated fabrication techniques—techniques that are geared to produce consistent results in products with internal micrometer dimensions. In talking with various memory manufacturers, we found that photolithography is the most widely used process in manufacturing large-scale integration (LSI) components.

Generally speaking, this process reduces wall-size circuitry drawings to microminiature pictures. These microminiature pictures are then used to form the desired circuitry on a base material such as silicon or garnet wafers. Currently, the typical line-width definition of LSI electronics is about 5 micrometers.

We found that most solid-state device manufacturers use conventional ultraviolet photolithography in an effort to consistently and reliably produce the smallest possible memory device with the highest capacity, fastest access time, and lowest power dissipation possible.

If the microminiaturization trends continue, and if smaller bit-storage areas of submicrometer dimensions are required, ultraviolet photolithography must be abandoned. Other, more expensive and sophisticated fabrication tools, such as x-ray and electron-beam lithography systems, must be installed to solve the submicron dimension problems.

Figure 1 shows a comparison in size between the still popular core memory system and a videodisk system. The donut-shaped figure represents the basic magnetic storage element of the core memory system. The tiny line in the center of the drawing represents the storage element of the videodisk system.

We found that the indicated size of 250 micrometers is the current state-of-the-art for an individual core. Cores are strung on several wires in order to gain electronic access to magnetically stored data. We were told by some manufacturers that the core is now stamped out of tape and that an assembler can string these parts as fast as 5,000 units an hour.

Inside the core of Figure 1, we show the cross section of a human hair, a smoke particle, a bit of silicon LSI memory, and finally a bit of videodisk information (see bottom line of Table 1).

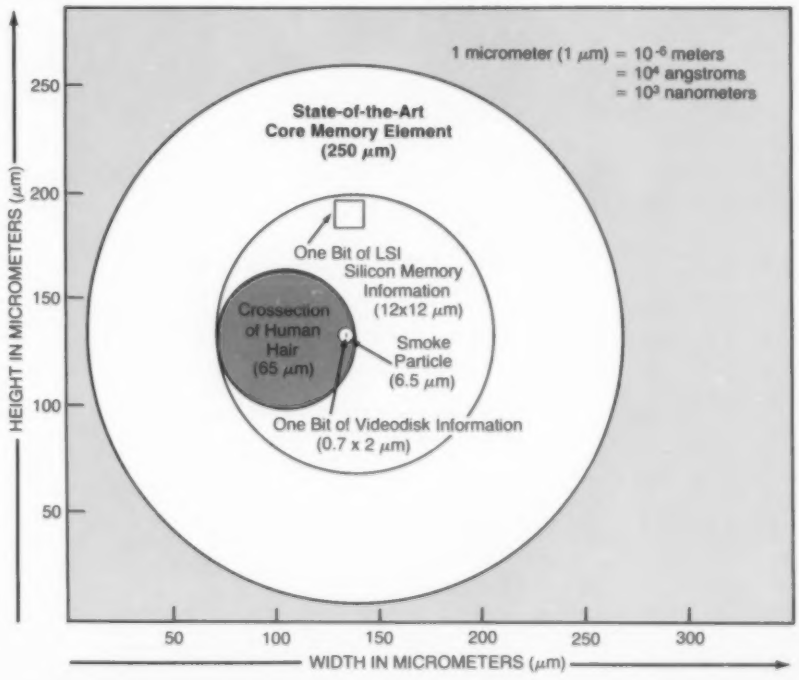
We found that videodisks are used in optical playback systems. These systems are now becoming available commercially. Videodisks can be used to store either analog or digital data and are currently available for use in television playback units for home entertainment. But lately a few manufacturers have been developing computer mass memories that are using the videodisk technology. One research facility believes that the following long term system performance characteristics are attainable: data rates to 50 megabits per second, access times in 10's of milliseconds, storage capacity of a quadrillion bits and a price of $10.00 per disk in quantities. (See Figure 1 for comparison). These goals suggest an approximate 3-order increase in capabilities over most current tape mass storage systems.

This read-only-memory system would make use of multiple disk packs and automatic disk changers. It could feature long-term (over 10 years), non-erasable data retention—characteristics which are desirable in a system for storing archival data.

Such a system, with a capacity of a quadrillion bits, according to one source could store more information than six million reels of tape. In fact, it could contain as much information as a small U.S. city would gather in two generations.

turn page

Figure 1—**Comparative Illustration Showing the Minute Size of a Bit of Videodisk Information.**



The space required to house the entire system would be strikingly small, especially in contrast to that needed for an information retrieval system with 6 million reels of tapes: One automatic information retrieval videodisk system would occupy roughly 9.3 square meters (100 square feet). The tapes would require about 3.2 hectares (8 acres) of system facilities.

The development of the videodisk system with the features we have described seems to contradict our predictions of solid-state substitution trends for mechanical rotating memories. On close observation, however, we conclude that this particular system has leapfrogged its way around contemporary solid-state memories by making direct use of advanced fabrication techniques such as electron beam and laser processing. By using these techniques, videodisk systems offer higher density storing capacities than any solid-state system that is currently fabricated by means of conventional photolithography. What's more, the detail of Figure 3 was taken from a disk pressed by the normal pressing procedure used in audio record fabrication. The master record was produced by the use of a laser cutter which controls the physical characteristics of each depression.

The videodisk data is determined by the distance between depressions and by the length of each depression. We compared the physical dimensions of these depressions with dimensions of contemporary LSI solid-state electronic components produced by the conventional photolithographic process. This comparison revealed that the videodisk line length definition is controlled to a few nanometers while LSI component line widths are controlled to a few micrometers.

We conclude that this enormous difference in fabrication control accounts for the vast data storage capacity of videodisk systems. We also predict that the introduction of videodisk memories should cause a major impact on near-future computer mass memory systems and their markets.

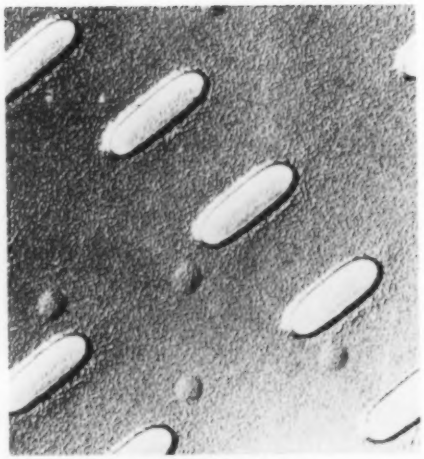


Figure 2—**A 10^4 Magnification of a Videodisk Surface.**

A NEW SELF BALANCING DC-SUBSTITUTION RF POWER METER

Licenses are now being offered for the manufacture and sale of the Type IV RF Power Meter described below (U.S. Patent No. 4,008,610). They may be obtained through the National Technical Information Service, U.S. Department of Commerce, 425 Thirteenth Street, N.W., Washington, D.C. 20004. The telephone number is 202/724-3374.

Neil T. Larsen, Electromagnetics Division, Room 3063, Boulder, Colo., 303/499-1000, ext. 3711 or 4444.

We have developed a new rf power meter that offers the advantages of lower cost, greatly simplified circuitry and construction, improved signal-to-noise ratio in the output signal, and the reduction or complete elimination of certain errors that are inherent in dc-substitution power meters that use a self-balancing Wheatstone bridge. This latter class of instruments includes virtually all commercial dc-substitution rf power meters. There is no compromise in the accuracy of the substituted dc power in the new meter which is not a form of Wheatstone bridge; in fact, the overall accuracy is improved.*

For many years, the highest accuracy in microwave power measurements in the range from 0.1 to 10 mW has been achieved with bolometers, using dc-substitution techniques. The first such precision instrument was a self-balancing Wheatstone bridge described by Engen in 1957 (1). In 1970, an improved self-balancing bridge with a built-in power-leveling capability was described by Larsen (2).

Figure 1 shows the form of the original self-balancing Wheatstone bridge, with a bolometer (T) (either a thermistor or a barretter) in one arm. The operational amplifier senses the error voltage across the horizontal diagonal of the bridge and drives the top of the bridge to heat the bolometer to a point such that its resistance very nearly balances the bridge. Obviously, the dc power dissipated in the bolometer may be computed on the basis of either the current through the bridge (1), or the voltage across it (2), since resistances of all of the arms are known. Voltage measurement offers the advantage of reduced error because no shunt need be used, and the system presents virtually a zero impedance source to the voltmeter. The voltage is measured before and after the rf power is applied, and the unknown rf power is related to the change in the computed dc power in the bolometer through the constants of the bolometer mount.

Active measuring circuits of various kinds incorporating operational amplifiers and isolated power supplies, as does the Type IV, are not new. However, the prior

*The new instrument, designated the NBS Type IV RF Power Meter, is smaller than the self-balancing bridge module of the NBS Type II Power Meter, which is currently the most accurate among commercially available rf power meters. The Type IV module supplants this part of the Type II unit.

work has dealt exclusively with linear systems involving linear (ohmic) resistances. In Figure 2, an operational amplifier and associated power supply are connected with two four-terminal resistors and an external voltage source in such a way that a current, I, flows through R1. Under the assumption of an ideal amplifier, the current will flow as shown, and because by hypothesis, no currents flow in the implifier input leads, exactly the same current flows out of the power supply common terminal back through R2 to the adjustable source. The amplifier maintains the current at such a level as to keep a zero potential difference between its input leads at all times. A voltmeter (V) connected between the other two potential terminals of R1 and R2 will display a reading which is proportional to the difference in resistance between R1 and R2.

Now consider replacing R2 by a negative-temperature-coefficient bolometer (a thermistor). If the source is varied, the current I will vary. This will cause the bolometer resistance to change. The changing resistance, as well as the changing current, will produce varying indications on the voltmeter. This suggests closing a second feedback loop in such a way as to control the source voltage by the voltmeter reading, to produce a voltmeter reading of zero. This concept is shown in Figure 3, where the voltmeter and source have now been replaced by a second operational amplifier and its power supplies. If a current, I, flows through R1, then by the previous argument, the current flowing through R2 must be identical. The amplifiers always maintain a zero potential difference across their respective inputs by controlling these identical currents. Thus, since R1 and R2 have identical voltage drops across them for identical currents, R2 must be equal to R1. This circuit therefore forces the bolometer resistance into equality with R1, and it does so on a four-terminal basis. This eliminates the lead-error problem intrinsic to the Wheatstone bridge. The circuit has two stable states, since the current can, in principle, flow equally well in either direction. However, once the current flow has been established, the self-balancing servomechanism is quite stable. It is a trivial matter to provide for a predetermined direction of flow in an actual instrument; for example, a diode may be placed in the current path.

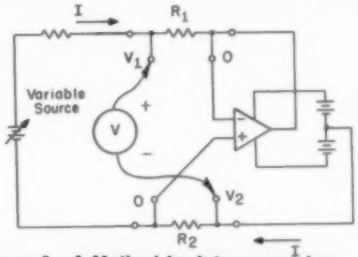


Figure 2—**A Method for Intercomparing Two Four-Terminal Resistors.**

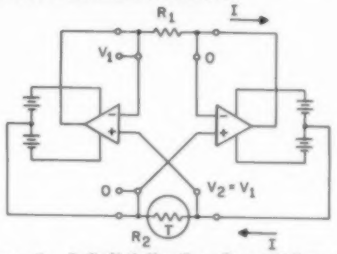


Figure 3—**A Self-Adjusting Current Loop.**

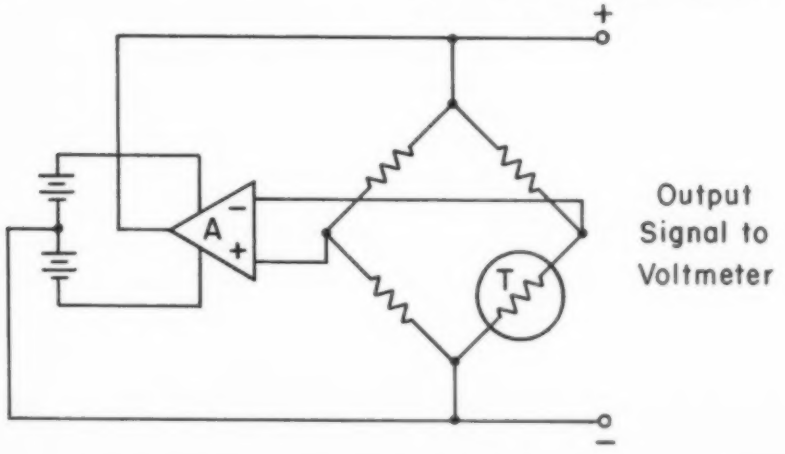


Figure 1—**Self-Balancing Wheatstone Bridge.**

The circuit also has interesting properties of symmetry. There are eight topologically different arrangements which all demonstrate the same principle. The unique features of this self-balancing circuit make the NBS Type IV especially attractive in applications where automatic control is desired. It is often necessary to assemble several power meters in a single system, one for each of several output ports. The use of four-terminal connections to both the internal reference resistor and to the bolometers makes it possible to bring long leads from the bolometer units to a central instrumentation console without introducing errors. In addition, it is now possible to control the operating resistance of the bolometer unit by changing the reference resistor in response to an electrical control signal. This is much more difficult to do in a Wheatstone bridge because the contact resistance of the switches cannot be entirely removed from the bridge circuit. Now, however, it is possible to use field-effect transistor switches with no degradation in the measurement accuracy.

(1) G. F. Engen, "A Self-Balancing Direct-Current Bridge for Accurate Bolometric Power Measurement," NBS J. Res., Vol. 59, No. 2, pp. 101-105, Aug. 1957.

(2) N. T. Larsen and F. R. Clague, "The NBS Type II Power Measurement System," Adv. Instrum. Vol. 25, Pt. 3, Paper No. 712-70, in Proc. 25th Annu. ISA Conf. (Philadelphia, PA), Oct. 26-29, 1970.

CONFERENCES

For general information on NBS conferences, contact Sara Torrence, NBS Office of Information Activities, Washington, D.C. 20234, 301/921-2721.

TIME AND FREQUENCY SEMINAR

The National Bureau of Standards will offer two seminars on time and frequency measurements in August and October 1977, at its Boulder, Colo., laboratories.

The first, entitled "Time and Frequency: Standards, Measurement, Usage," runs from August 22 through August 26 and is intended for engineers and scientists involved in the research, design, specification, use, or systems application of precision frequency standards and clocks. The second seminar is on "Time and Frequency Calibrations: Methods and Resources." It will run from October 17 through October 19 and is intended for engineers, scientists, and laboratory technicians who use time and frequency signals.

"Time and Frequency: Standards, Measurement, Usage" is presented by the Frequency-Time Standards Section. The seminar covers concepts and designs of measurement systems and standards, environmental effects and their reduction, clock models and time scales, and more, in presentations by NBS experts and invited scientists, panel discussions, and laboratory visits. Cost of this seminar is $500 (lodging and meals not included).

For further information contact: Patsy Tomingas, 277.04, NBS, Boulder, Colo., 80302, 303/499-1000, ext. 3276.

The seminar on "Time and Frequency Calibrations: Methods and Resources" will cover practical calibration methods, equipment, and sources of standard time and frequency signals, such as WWV, WWVB, etc. Emphasis will be on choosing among available time and frequency services and techniques to solve a given application problem and hands-on laboratory experience will be offered. The $300 fee (due by September 30) includes all materials and supplies, but not food and lodging.

For further information contact: Jeannette Detter, 277.06, NBS, Boulder, CO, 80302, 301/499-1000, ext. 3212.

ROOFING SYMPOSIUM

The symposium, jointly sponsored by the National Bureau of Standards and the National Roofing Contractors Association (NRCA), will be held September 21 through 23, 1977, at the NBS facility in Gaithersburg, MD.

Roofing researchers and contractors from around the world will meet for the first time in the United States to exchange technical information on the science and technology of membrane roofing at a Symposium on Roofing Technology at NBS.

International roofing technologists will present papers dealing with materials, designs, construction, and performance aspects of membrane roofing. They will report the latest developments in roofing applications and practices. The conference will include sessions on insulation and energy conservation, moisture in roofing, and performance characteristics of roofing systems.

The opening session will consist of presentations of roofing practices throughout the world. Speakers for the initial session include: Robert E. Linck, Warren-Ehret-Linck Company, Philadelphia, PA; J. M. Roy, Roy Roofing, Ltd., Leeds, England; Lars Erik Nevander, Lund Institute of Technology, Sweden; Michio Koike, Tokyo Institute of Technology, Japan; and Hans Egger, Meynadier Company, Zurich, Switzerland.

A complete manuscript of all symposium presentations will be published in a proceedings volume which registrants will receive at the time of registration.

NBS and NRCA have cosponsored four national conferences on roofing technology on a bi-annual basis beginning in 1969. This symposium is an extension of these national conferences and attendance by roofing researchers and contractors from other countries is encouraged.

For further information contact: William A. Good, NRCA headquarters, 1515 North Harlem Ave., Oak Park, Ill., 60302 or William C. Cullen, B368 Building Research Building, 301/921-2196, or Robert G. Mathey, B340 Building Research Building, 301/921-3047.

COMPUTER PERFORMANCE-EVALUATION USERS GROUP

The 13th meeting of the Computer Performance-Evaluation Users Group will be held October 11-14, 1977. Within the last several years the field of computer performance evaluation (CPE) has evolved from a handful of dedicated practitioners to an accepted and necessary technology, with application throughout the total ADP life cycle. Founded in 1971 by the U.S. Air Force and now sponsored by the National Bureau of Standards, CPEUG has been in the forefront of this evolution both as a forum for information exchange and as a catalyst for defining new directions. Although CPEUG has its roots in the federal establishment, its appeal to the entire ADP community is evidenced by the growing involvement of the private sector.

In spite of its phenomenal growth, CPE is still experiencing the growing pains natural to any maturing technology. Consequently, a few areas are characterized by considerable progress while efforts in other areas are splintered and duplicative. An accepted framework for viewing and directing these efforts—a necessary ingredient for CPE to fully mature—has not emerged.

The structural basis for this year's conference—and for succeeding conferences—will be the ADP life cycle. This structure is intended to provide for a logical development of topical areas across and within sessions, as well as between conferences.

The conference will consist of technical sessions, workshops, tutorials, and vendors sessions. Proceedings of the conference will appear as a special NBS publication.

For further information contact: Dr. Dennis M. Conti, A265 Technology Building, 301/921-3485.

CONFERENCE CALENDAR

August 22-26
TIME AND FREQUENCY: STANDARDS, MEASUREMENTS, USAGE, NBS, Boulder, Colo.; sponsored by NBS; contact: Helmut Hellwig, NBS, Boulder, Colo., 303/299-1000, ext. 327.

September 7-8
SEMINAR ON EARTHQUAKE DESIGN CRITERIA, STRUCTURAL PERFORMANCE, AND STRONG MOTION RECORDS, NBS, Gaithersburg, MD; sponsored by NBS, EERI; contact: Dr. Richard Wright, B244 Building Research Building, 301/921-3377.

September 21-23
SYMPOSIUM ON ROOFING TECHNOLOGY, NBS, Gaithersburg, MD; sponsored by NBS and the National Roofing Contractors Association; contact: Robert G. Mathey, B348, Building Research, 301/921-3407.

September 28-30
DATA ELEMENT MANAGEMENT SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and ANSI Committee X3L8; contact: Hazel McEwen, B226 Technology Building, 301/921-3157.

October 3-6
ALTERNATIVES FOR CADMIUM ELECTROPLATING IN METAL FINISHING, NBS, Gaithersburg, MD; sponsored by NBS, Consumer Product Safety Commission, Department of Defense, Department of Interior, Occupational Safety and Health Administration, Environmental Protection Agency, Food and Drug Administration, and General Services Administration; contact: Fielding, Ogburn, B166 Polymers Building, 301/921-2957.

October 11-13
MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS, Gaithersburg, MD; sponsored by NBS, Energy Research and Development Administration, Electric Power Research Institute; contact: S. J. Schneider, B303, Materials Building, 301/921-2893.

October 11-14
COMPUTER PERFORMANCE EVALUATIONS USERS GROUP, 13th MEETING, New Orleans, LA.; sponsored by NBS; contact: Dennis Conti, A248 Technology Building, 301/921-3861.

October 17-19
TIME AND FREQUENCY CALIBRATION: METHODS AND RESOURCES, NBS, Boulder, Colo.; sponsored by NBS; contact: Roger Beehler, NBS, Boulder, Colo., 303/499-1000, ext. 3281.

October 19-20
RELIABILITY TECHNOLOGY FOR CARDIAC PACEMAKERS, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry A. Schafft, A327 Technology Building, 301/921-3625.

November 1-3
MECHANICAL FAILURES PREVENTION GROUP, NBS, Gaithersburg, MD; sponsored by NBS and MFPG; contact: Harry C. Burnett, B260 Materials Building, 301/921-2818.

November 13-17
WORKSHOP ON RAPID SOLIDIFICATION TECHNOLOGY, Sheraton-Reston, Reston, VA; sponsored by NBS, ARPA; contact: Dr. Arthur Ruff, B264 Materials Building, 301/921-2811.

December 5-7
WINTER SIMULATION CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS, the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, Operations Research Association of America, the Institute for Industrial Engineers, and the Society for Computer Simulation; contact: Paul F. Roth, B250 Technology Building, 301/921-3545.

1978

April 10-13
TRACE ORGANIC ANALYSIS: A NEW FRONTIER IN ANALYTICAL CHEMISTRY, NBS, Gaithersburg, MD; sponsored by NBS; contact: Harry S. Hertz, A105 Chemistry Building, 301/921-2153.

April 17-20
ACOUSTIC EMISSION WORKING GROUP MEETING, NBS, Gaithersburg, MD; sponsored by NBS; contact; John A. Simmons, B118 Materials Building, NBS, 301/921-3355.

April 23-26
AMERICAN NUCLEAR SOCIETY TOPICAL CONFERENCE ON COMPUTERS IN ACTIVATION ANALYSIS AND GAMMA RAY SPECTROSCOPY: Mayaguez, Puerto Rico; sponsored by NBS, American Chemical Society, American Nuclear Society, Energy Research and Development Administration, U. of Puerto Rico, Puerto Rico Nuclear Center; contact: B. S. Carpenter, B108 Reactor Building, NBS, 301/921-2167.

May 8-10
SYMPOSIUM ON REAL-TIME RADIOGRAPHIC IMAGING, NBS, Gaithersburg, MD; sponsored by NBS and the American Society for Testing and Materials; contact: Donald A. Garrett, A106 Reactor Building, 301/921-3634.

*June 26-29
CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS, Ottawa, Ontario, Canada; sponsored by Institute of Electrical and Electronics Engineers, U.S. National Committee-International Union of Radio Science, and NBS; contact: Dee Belsher, NBS, Boulder, Colo., 303/499-1000, ext. 3981.

*New listing

TEACHER AIDS

For science teachers around the nation, the federal government is one of the best potential sources of publications and audiovisual materials suitable for classroom use. From aeronautics to zoology, a wealth of material is available free-of-charge or at low cost.

As a service to teachers, science departments, school libraries, and students, DIMENSIONS/NBS is beginning to collect and review printed material and gather information on audio/visual items available from federal agencies. Listed below are a few of the many selections we feel would be of value to teachers and students. Future issues of the magazine will carry similar reviews.

Publications

Energy History of the United States—1776-1976

Wall chart and accompanying User's Manual, *So What's New?* A graphic presentation focusing on wood, coal, animal energy, wind and water, gaseous fuel, liquid fuel, electricity, solar and geothermal, and nuclear energy.

Single copies free to educators. Order from:

Energy Research and Development Administration
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

Four booklets on modern astronomy and its "new view of the universe":

The Supernova (EP-126)

Chemistry Between the Stars (EP-127)

Atoms and Astronomy (EP-128)

Extragalactic Astronomy (EP-129)

Prepared as a curriculum project of the American Astronomical Society with the cooperation of the National Aeronautics and Space Administration (NASA) and the National Science Foundation. Single copies are available free to educators. Order from:

National Aeronautics and Space Administration
Educational Programs Division [F.E.]
Washington, D.C. 20546

What's New on the Moon? (EP-131)

Illustrated booklet by a geologist specializing in research on lunar samples, meteorites, and ancient meteorite craters. It has won an award for editorial excellence. Single copies free to educators. Order from NASA Educational Programs Division, as indicated above.

Space Shuttle (EP-96)

Picture booklet illustrating the space craft and its mission in full color paintings. Single copies free to educators. Order from NASA Educational Programs Division, as indicated above.

Space: Environmental Vantage Point

Meteorological satellites relaying "a near-continuous view of the earth's surface"—a powerful new aid to environmental monitoring and disaster preparedness—are described. Excellent and abundant illustrations are the highlight of this booklet produced by the National Oceanic and Atmospheric Administration. The text discusses interdisciplinary work by meteorologists, oceanographers, aeronomers, geodesists, geologists, seismologists, hydrologists, geomagneticians, and marine biologists. For sale at $1.15 a copy (Stock No. 0317-00259). Order from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Audio-Visual Material

Flood!

A 15-minute, 16 mm sound/color film available on free loan from the National Oceanic and Atmospheric Administration. The film describes precautions that can be taken to minimize damage from flooding, shows the development and impact of floods caused by seasonal snowmelt, hurricanes and heavy rainstorms, and concludes with a description of the deadly flash flood. For free loan (no charge except for return postage), contact:

Motion Picture Service
Department of Commerce-NOAA
12231 Wilkins Avenue
Rockville, Maryland 20852
Phone: 301/443-8411.

For information on film purchases, contact:

Order Section
National Audiovisual Center
General Services Administration
Washington, D.C. 20409

The Safest Place in Schools

This slide lecture (140 2x2 color slides with written narrative), produced by the National Oceanic and Atmospheric Administration, shows the destructive effects of tornadoes and the most dangerous and safest areas in schools or other buildings of similar design. For current information on availability and price of the slide lecture, contact:

Order Section
National Audiovisual Center
General Services Administration
Washington, D.C. 20409

The NBS Metric Kit

Updated materials helpful to educators, consumers and business managers as the nation increasingly adopts the metric system of measurement. The packet includes: the popular brochure, "What About Metric?" ; a color chart of the metric system; an explanatory message from the Bureau's director; "America Joins a Metric World," reprint of an article from DIMENSIONS/NBS, the Bureau's monthly magazine; a wallet-sized conversion card, and a 15-cm ruler. The kit is for sale at $2 (NBS Special Publication 410, Stock No. 0303-01347). Order from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

PUBLICATIONS OF THE NATIONAL BUREAU OF STANDARDS

Building Technology

Milton, H. J., *Recommended Practice for the Use of Metric (SI) units in Building Design and Construction*, Nat. Bur. Stand. (U.S.), Tech. Note 938, 47 pages (Apr. 1977) Stock No. 003-003-01761-2, $1.60.

Computer Science and Technology

Watkins, S. W., and Abrams, M. D., *Computer Science and Technology: Survey of Remote Terminal Emulators*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-4, 80 pages (Apr. 1977) Stock No. 003-003-01756-6, $1.45.

Warnar, R. B. J., *Computer Science and Technology: Impact of Charge-Transfer Device Technology on Computer Systems*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-5, 48 pages (Apr. 1977) Stock No. 003-003-01758-2, $1.10.

Cotton, I. W., *Computer Science and Technology: Computer Network Interconnection: Problems and Prospects*, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-6, 83 pages (Apr. 1977) Stock No. 003-003-01757-4, $1.45.

Health and Safety

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HUD ESTABLISHES SOLAR STANDARDS. The Department of Housing and Urban Development (HUD) has established quality levels for solar heating and domestic hot water systems for residences designed and constructed under HUD programs. The solar standards, which were developed for HUD by NBS, are a supplement to HUD's Minimum Property Standards (MPS). MPS define the minimum level of quality acceptable for nursing homes, intermediate care facilities, and single- and multi-family residences designed and constructed under HUD programs.

NBS TO STUDY CRITERIA FOR HIGHWAY NOISE. How annoying is highway traffic noise? Engineers and psychoacousticians at NBS are helping the Department of Transportation answer that question. The researchers are using real and simulated tapes of highway traffic noise in a project to identify and quantify important acoustic properties which affect human response to variable traffic noise. The data will be used by the Federal Highway Administration to improve noise standards for highway design in projects receiving federal aid.

RESEARCH AND INNOVATION IN THE BUILDING REGULATORY PROCESS. A joint conference sponsored by NBS and National Conference of States on Building Codes and Standards (NCSBCS) will be held on September 20, 1977, at Bozeman, Montana; contact: Patrick Cooke, B226 Building Research, 301/921-3361.

SYMPOSIUM FEATURES PRODUCT DURABILITY. NBS will hold a symposium November 1-3 in Gaithersburg, Md., on product durability and life. The meeting is the 27th in a continuing series of conferences devoted to various aspects of the prevention of mechanical failures and is sponsored by the Mechanical Failures Prevention Group. For more information, write or call Harry C. Burnett, B264 Materials Building, NBS, Washington, D.C. 20234, 301/921-2813.

NBS SCIENTISTS WIN THREE AWARDS IN 1977 I-R COMPETITION. Inventions for the precise measurement of time and space won three awards for scientists from the National Bureau of Standards in a competition sponsored by Industrial Research magazine for the 100 most significant new technical products in 1977. The NBS winners are D. Wayne Hanson of the Institute for Basic Standards for development of a highly accurate satellite-controlled clock; David B. Ballard, Fielding Ogburn, and John P. Young of the Institute for Materials Research for development of a micrometer scale for calibrating scanning electron microscopes; and John L. Hall of the Institute for Basic Standards, together with Siu-Au Lee of the University of Colorado, for development of an accurate and extremely fast laser wavelength meter.

NEXT MONTH IN

DIMENSIONS/NBS

A new government program may take much of the guesswork out of shopping for consumer products. The Department of Commerce wants manufacturers to participate in a voluntary program to label products with information on how they will perform. Read about performance labeling in the September issue of DIMENSIONS/NBS.

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Prepared by the NBS Office of Information Activities
Washington, D.C. 20234
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PHOTO CREDITS:
Steve Henneman: Cover
Mark Helfer: pages 2-7 and 14-15

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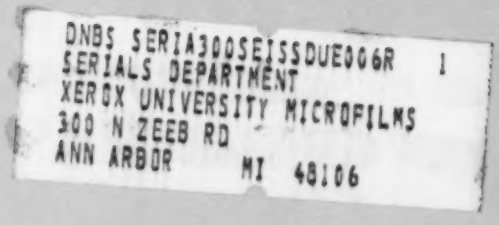
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